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Interim Report # 1

ALDRIN EVALUATION AREAS - 1967

of the

EVALUATION OF THE WHITE GRUB PROBLEM IN RED PINE PLANTATIONS OF THE LAKE STATES

Prepared by

Richard F. Fowler

Entomologist

St. Paul State and Private Forestry Field Office

Northeastern Area, State and Private Forestry

U. S. Forest Service, St. Paul, Minnesota

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INTRODUCTION

The "white grub", the larval stage of the genus Phyllophaga and several species of other genera (Coleoptera, Scarabaeidae), has been blamed for serious losses of young pine in plantations. An evaluation plan[1] by Fowler and Wilson[2] was prepared in 1967 in time to begin the field work with the spring planting season of 1967. The objectives of the plan are as follows:

1. To evaluate the effectiveness of the currently used methods of applying aldrin as a means of grub control.

2. To survey the grub population in the red pine plantations in order to determine the population and distribution of the white grubs and the species present.

3. To survey young red pine plantations in the Lake States in order to measure the damage presently attributable to the feeding by grubs on the roots of the trees, and to correlate this damage with the population found.

4. To evaluate the use of measurable ecological factors as a tool to aid in the prediction of possible grub losses during the preplanting inspection of proposed planting sites.

This report covers the work and results to date on Objective 1.

Five aldrin evaluation areas were established on the Hiawatha National Forest during the spring of 1967 (see Establishment Report[3]). The treatments used in these areas were as follows:

1. Machine planted trees with the aldrin solution applied at the time of planting using an attachment to the planting machine.

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1. Fowler and Wilson. 1967. Evaluation plan for evaluation of the white grub problem in red pine plantations of the Lake States. St. Paul, Minn. 25 p.

2. Entomologist - St. Paul State and Private Forestry Field Office, State and Private Forestry, St. Paul, Minn; and Insect Ecologist - North Central Forest Experiment Station, East Lansing, Mich., respectively.

3. Fowler. 1967. Establishment Report - aldrin evaluation areas on the Hiawatha National Forest Upper Peninsula of Michigan. St. Paul, Minn. 16 p.

2. Machine planted trees with aldrin solution applied soon after planting using the "aljector" (hand applicator developed by the Hiawatha National Forest).

3. Machine planted trees with the recommended dose of granular aldrin applied at the time of planting using an attachment to the planting machine.

4. Machine planted trees with no aldrin applied - as a control plot.

Red pine (Pinus resinosa) planting stock was used in the evaluation plots. This is the major reforestation species in the Lake States at the present time.

Fowler has personally conducted the survival counts and digging of the living trees and has done all of the root scoring. These counts and sampling of living trees were done in September of 1967 following the first growing season. The living trees to be dug for root scoring were randomly selected from each treatment after the dead trees had been recorded. The areas will be re-examined yearly.

The grub population survey was conducted by three summer students in June 1967 under the direction of the entomologist. The survey will be repeated each year of the evaluation.

METHODS

Evaluation Areas

The location of the five evaluation areas are listed below. See the Establishment Report for maps and planting data.

Area	District	Location
Raco CCC Camp	Sault Ste. Marie	T46N, R4W, Sec 24
Highbanks Lake	Sault Ste. Marie	T46N, R5W, Sec 13
Town Hall(Strongs)	Sault Ste. Marie	T46N, R6W, Sec 36
Townline Lake	Munising	T45N, R18W, Sec 34
Bird Area	Manistique	T44N, R18W, Sec 29

Grub Population Survey

Soil sampling for white grubs was carried out in June by three summer students. Thirty 1-cubic-foot samples were taken systematically across the five blocks comprising the area. Six samples were taken in each block. A line was run across the middle of the block and the samples were taken between rows 2 and 3, 6 and 7, 10 and 11, 14 and 15, 18 and 19, and 22 and 23 from left to right, facing from block I toward block V. (See diagram below).

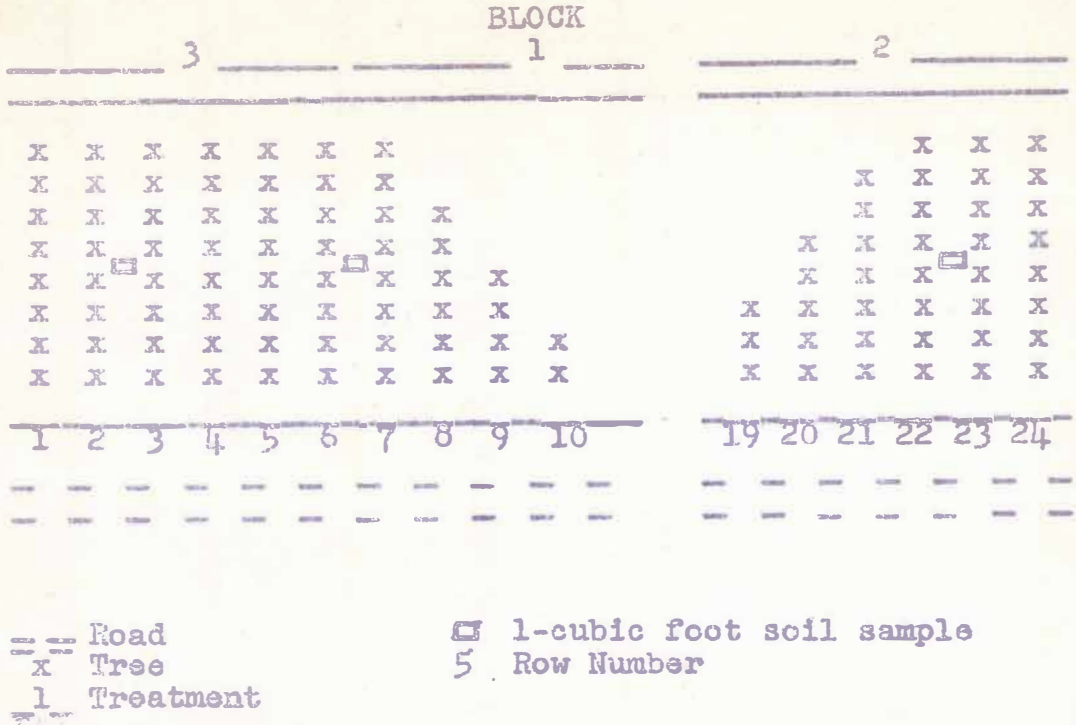


Fig. 1: Arrangement of 1-cubic foot soil samples across a block.

The initial population survey was designed to represent the grub population as it was before the area was disturbed by the spring planting operation. To accomplish this, each sample was "chosen" to the extent that the cubic foot of soil to be used was undisturbed either by the planting machine or the tractor. (It was noted that some grubs emerged from the tractor tread marks shortly after the tractor had passed.)

The 1-cubic-foot of soil measured one square foot on the surface of the ground and one foot deep. The entomologist sampling deeper than one foot during the summer of 1966 (a very dry year) found that a depth of one foot was sufficient to include essentially all the grubs in the soil profile.

Each man participating in the survey had an iron cube, open on the top and bottom, with inside dimensions of one foot in each direction. This cube was driven into the ground to its total depth, isolating the desired cubic foot of soil and also preventing sand around the sides of the hole from caving in.

The surface vegetation of the sample was cut off at the ground level. The root mass was then removed to a wooden-frame screened with ¼" hardware cloth. The mass was torn apart for grubs; however all insects found were preserved. The grubs found were tallied on the field data sheet as they were placed in the vial.

The soil was sifted through the ¼" screen (previous work showed

that sifting through a finer mesh-window screen -was unnecessary and laborious) and all stages of the June beetle and all other soil insects were placed in vials and preserved for later identification.

Root Damage Rating System

A numerical rating system modified from Johnston and Eaton, was used to classify grub damage. The scoring system as originally used in this work ranged from 1 to 5 using whole numbers. The damage classes ranged from 1: no roots cut off to 5: all roots cut off.

Survival Counts

The entomologist made the survival counts during the period of September 7 - 20. All the trees in each treatment was examined and judged to be living or dead. The date that each tree was found dead was recorded in the appropriate column on the data sheet. The tree was dug, examined for signs of other insects and disease, and the root system scored.

Sampling Living Trees

In addition to the digging of the dead trees to examine and score the roots, ten living trees from each treatment in every block were dug and their root systems examined and scored. This was done to measure sub-lethal damage caused by grub feeding. This phase of the evaluation was done during the period of September 15 - October 5.

The ten living trees that were dug were randomly selected by pulling numbers out of a hat. Since there were ninety trees in each treatment of every block (15 trees per row X 6 rows), the numbers used were 1 through 90. Thirteen numbers were selected and written on a card in the order selected. A check mark was placed on the data sheet next to each tree selected. If that tree was already dead (the selections were made after the survival count had been made and the dead trees recorded) this number was discarded and the number selected on the eleventh drawing was used so that a total of ten living trees were selected from each treatment. This method was found to be faster than hunting through the data sheets after drawing each number to find the tree selected.

RESULTS

White grub populations were quite varied among the aldrin eval-

uation areas. The results of the survey were as follows:

	Raco	High banks Lk.	Town-hall	Town-line Lk.	Bird Area
No. samples	30	30	30	30	30
Grubs/area	33	7	37	42	10
Grubs/ft.^{3}	1.10	0.23	1.23	1.40	0.33
Damaging pop.*	0.50	0.50	0.50	0.50	0.50

* Tentatively set by Shenefelt, R. D., H. R. Liebig, and R. C. Dosen. 1954. Protecting machine transplanted trees from white grubs. Univ. of Wis. Forest Res. Note 47; 3 p.

Root Damage Rating System

The modified root rating system used in this evaluation is as follows:

Class 1 - all roots intact.
Class 2 - roots cut or broken off but no sign of grub feeding.
Class 2½ - one third or less of the fibrous roots cut off by grub feeding (includes cutting of larger roots that removes this amount of fibrous roots).
Class 3 - more than one third but less than two thirds of fibrous roots cut off (includes cutting of larger roots that removes this amount of fibrous roots).
Class 3½ - two thirds or more but not all of the fibrous roots cut off (includes cutting of larger roots that removes this amount of fibrous roots).
Class 4 - all fibrous roots cut off; tips of larger roots may or may not be cut off; cambium may or may not be stripped.
Class 5 - larger roots cut off; portions of the tap root may or may not be cut off; probably some cambium stripped; or tap root cut off just below surface of the ground.

Survival Counts

The survival counts were quite high as is often the case at the end of the first growing season. The percentage of dead trees in each damage group is presented in Table 1. The three damage categories used are: undamaged trees having a root score of 1 or 2, moderately damaged trees having a root score of 2½ or 3, and heavily damaged trees having a root score of 3½, 4 or 5.

Table 1: 1967 RESULTS BY TREATMENTS OF ROOT SCORING DEAD AND SAMPLED LIVING TREES

Area	Treatment	Grubs Per Cu. Ft.	Survival [1]	Grub Feeding Damage of Dead Trees [1]				Grub Feeding Damage of Trees Dug Living			
				No. Trees [2]	% Undamaged [3]	% Moderate [4]	% Heavy [5]	No. Trees	% Undamaged [3]	% Moderate [4]	% Heavy [5]
Highbanks [6]	1	0.23	97.2	8	25.0	37.5	37.5	10	100.0	----	----
	2			8	50.0	25.0	25.0	10	100.0	----	----
	3			15	100.0	----	----	10	100.0	----	----
	4			19	57.9	5.3	36.8	10	90.0	----	10.0
Bird Area	1	0.33	98.4	3	33.3	66.7	----	50	78.0	14.0	8.0
	2			9	66.7	----	33.3	50	88.0	10.0	2.0
	3			4	75.0	----	25.0	50	86.0	14.0	----
	4			12	58.3	8.4	33.3	50	68.0	14.0	18.0
Raco	1	1.10	97.3	14	71.4	28.6	----	50	84.0	16.0	----
	2			9	100.0	----	----	50	74.0	18.0	8.0
	3			11	72.7	9.1	18.2	50	92.0	6.0	2.0
	4			14	28.6	21.4	50.0	50	68.0	14.0	18.0
Townhall	1	1.23	96.0	21	81.0	9.5	9.5	50	88.0	12.0	----
	2			15	60.0	20.0	20.0	50	78.0	20.0	2.0
	3			10	100.0	----	----	50	78.0	14.0	8.0
	4			26	61.6	19.2	19.2	50	62.0	20.0	18.0
Townline Lk.	1	1.40	97.7	3	----	33.3	66.7	50	56.0	16.0	28.0
	2			13	46.2	23.1	30.7	50	58.0	28.0	14.0
	3			13	92.3	7.7	----	50	56.0	16.0	28.0
	4			13	38.5	23.0	38.5	50	48.0	10.0	42.0

1 - Based on 1800 trees examined
2 - Based on 450 trees examined in each treatment
3 - Root scores of 1 and 2
4 - Root scores of 2½ and 3
5 - Root scores of 3½, 4, and 5
6 - Sampling of living trees was not completed in this area

Sampling Living Trees

The results of the digging of living trees to obtain a measure of sub-lethal grub damage are also presented in Table 1. The same three damage categories are used here as with the trees dead at the survival counts.

DISCUSSION

Grub Population Survey

The white grub survey carried out in 1967 showed that the white grub population in three of the five aldrin evaluation areas was higher than ½ grub per cubic foot of surface soil, the figure tentatively set as a damaging population. The gross population figures are used in this report since the taxonomic work is not completed.

Root Damage Rating

Early in the root scoring process it was noted that a score of 1 was extremely rare because roots are cut in the process of root pruning and are also broken off in handling. Class 2 was used to reflect roots that had been cut or damaged by agents other than grub feeding. These two classes should be combined for field use and called Class 1, but they will be kept separate during the remainder of this evaluation to avoid any confusion and for the sake of uniformity.

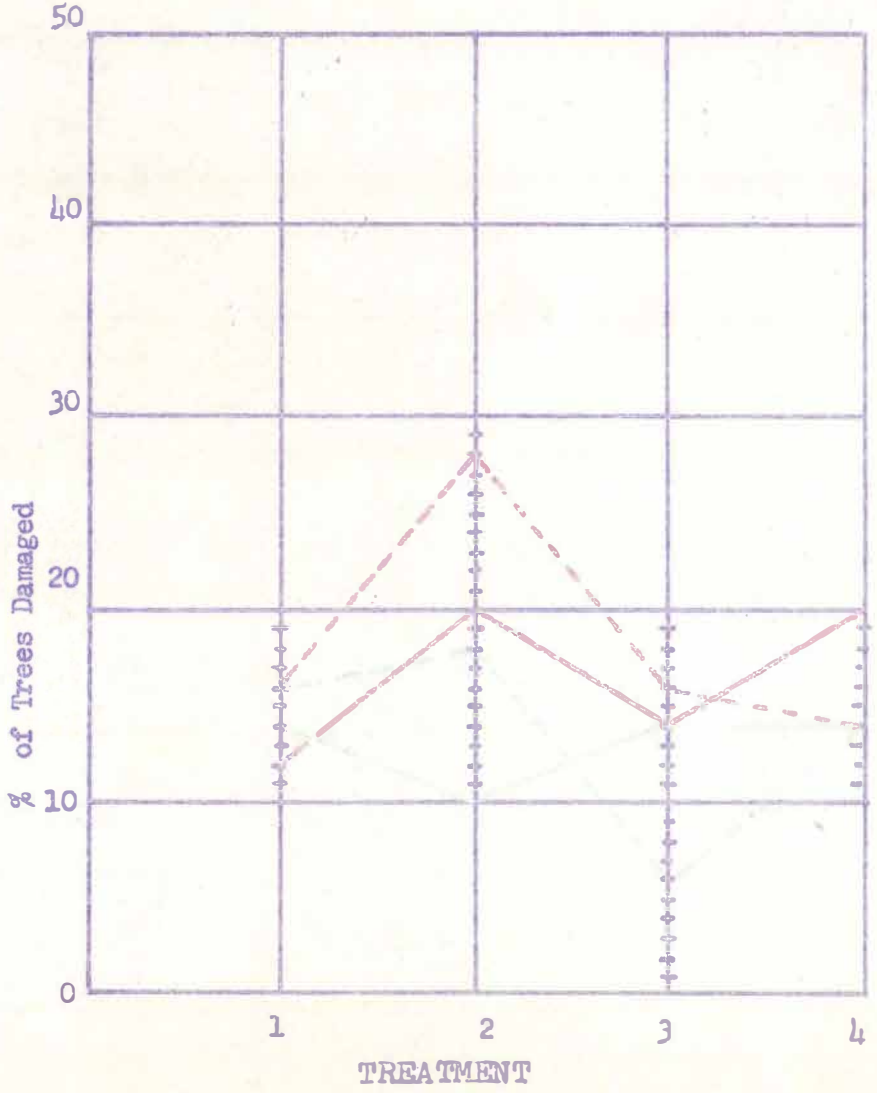
Both Classes 4 and 5 have had all the fibrous roots cut off. The difference between the two lies in the degree and type of damage done to the larger lateral roots and the tap root. These two classes should also be combined in practice and called Class 5.

These uses of the class designations left only Class 3 to indicate various degrees of feeding on the fibrous roots. Classes 2½ and 3½ were set up to take care of this. The seven classes used in this evaluation were defined earlier under Results.

Sampling Living Trees

Ten living trees per treatment were dug to obtain a measure of sub-lethal grub damage. Every class of grub feeding damage was found on these trees. In fact some of these trees were completely stripped of roots and for all practical purposes were dead. Some of these trees could not even be classified as off color but they will fade in time.

GRAPH 1. ROOT SYSTEMS MODERATELY DAMAGED BY GRUB FEEDING - LIVING TREES



ALDRIN EVALUATION AREAS

Bird Area — Townhall
Raco — Townline Lk.

TREATMENTS

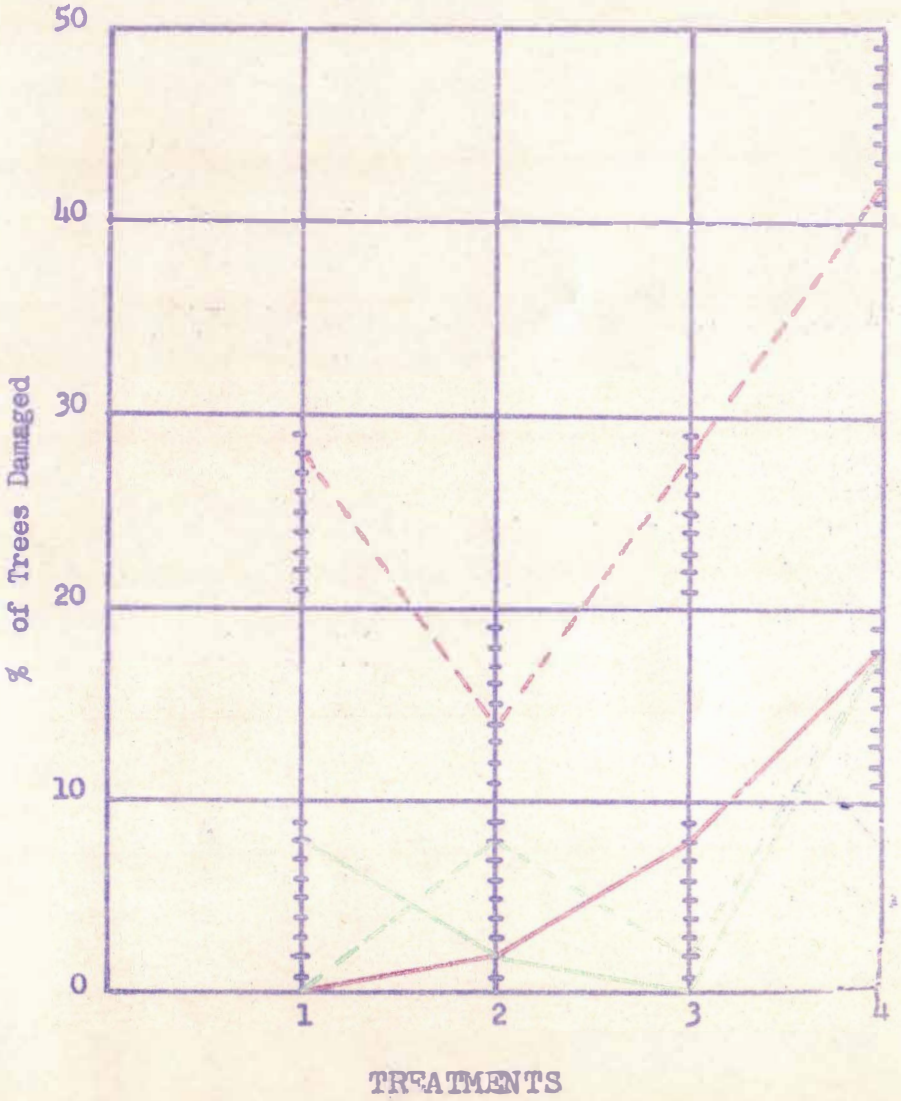
1 - Liquid Aldrin Applied by Planting Machine

2 - Liquid Aldrin Applied by Hand Applicator

3 - Granular Aldrin Applied by Planting Machine

4 - Check - No Aldrin

GRAPH 2. ROOT SYSTEMS HEAVILY DAMAGED BY GRUB FEEDING - LIVING TREES



ALDRIN EVALUATION AREAS

Bird Area — Townhall
Raco - - - Townline Lk.

TREATMENTS

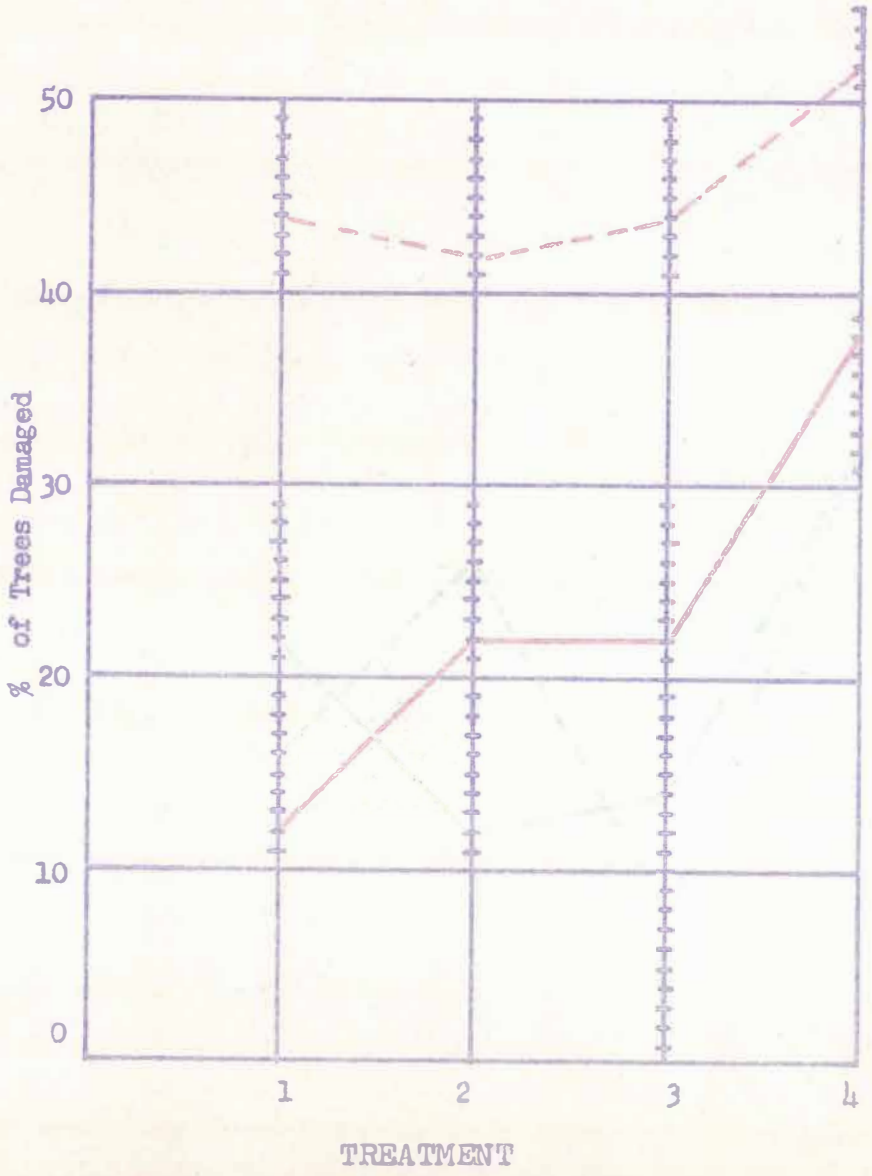
1 - Liquid Aldrin Applied by Planting Machine

2 - Liquid Aldrin Applied by Hand Applicator

3 - Granular Aldrin Applied by Planting Machine

4 - Check - No Aldrin

GRAPH 3. ALL ROOT SYSTEMS DAMAGED BY GRUB FEEDING - LIVING TREES



ALDRIN EVALUATION AREAS

Bird Area — Townhall
Raco — Townline Lk.

TREATMENTS

1 - Liquid Aldrin Applied by Planting Machine

2 - Liquid Aldrin Applied by Hand Applicator

3 - Granular Aldrin Applied by Planting Machine

4 - Check - No Aldrin

The data from Table 1 has been plotted on Graphs 1, 2 and 3. The three graphs depict the trees in the moderately damaged category (root scores 2½ and 3), the trees in the heavily damaged category (root scores 3½, 4 and 5), and the total percent of damaged trees (the sum of the moderately and heavily damaged trees). Each area is represented by a different line and each treatment is plotted separately.

The graph of the moderately damaged trees shows a lack of consistency within the performance of each treatment. In one area a certain treatment appears to be the best but this same treatment in another area appears to give the least amount of protection. Further it is noted that in some cases treating with aldrin seems to offer less protection than no aldrin at all (Treatment 4). Actually a higher percentage of the untreated trees fall into the heavily damaged category. This would indicate that the unprotected trees are fed on longer than the treated trees. Farmer's Bull. No. 1798* states that the grubs feed for some time after being poisoned. This may be the case in the aldrin evaluation areas. Although the trees had been treated with aldrin, from 6 to 20% of these trees (excluding Townline Lake area where the grub population is the heavist) were moderately damaged. Only an additional 0 to 8% of the trees were heavily damaged; but it is not inconceivable that these heavily damaged trees were missed when the aldrin was applied.

At Townline Lake, however, 16 to 28% of the treated trees were moderately damaged and an additional 14 to 28% of the trees were heavily damaged. More investigation is needed in this area to see why aldrin was so ineffective.

The patterns described above are modified when the two damage categories are combined (Graph 3). In all areas the untreated plots had a higher percent of damaged trees. However, the failure of any aldrin treatment to give consistent results in all areas is still apparent. These inconsistent results led to the recommendations at the end of this report for the 1968 spring planting season.

The data in Table 1 was analyzed statistically using the F "t" and Duncan Range Tests. For these tests two groupings of the data was used. First all the damaged trees (root scores of 2½ to 5) were analyzed as a group, and second just

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* Anonymous. 1959. Control of common white grubs in cereal and forage crops. Farmer's Bull. 1798. USDA. 13 pp.

the heavily damaged trees (root scores 3½ to 5) were used.

The analysis of the group containing all the damaged trees gave the results discussed here. The values of the F test were not significant at the 5% level in any of the four areas where data collecting was completed (see Table 2). The values of the "t" were not significant at the 5% level in the three areas that have a grub population exceeding the ½ grub per cubic foot established as a damaging population. The only area where "t" was significant was in the Bird Area where the population is below that considered as damaging. The Duncan Range Test was used as a check against the "t" test. Where discrepancies could not be resolved, the "t" test was chosen as being more sensitive.

When the group containing only the heavily damaged trees was analyzed, the following results were obtained. The F test showed significance between the treatment means and the control mean only in the Townhall Area. Also in this area both treatments 1 and 2 were significantly less damaged than the check treatment when compared with the "t" test at the 5% level. The Duncan Range Test agrees in this case. The value of "t" is not significant when Treatment 3 is compared with Treatment 4 nor are any of the three aldrin treatments significantly different at the 5% level from any other aldrin treatment in this area.

The data in Table 3 shows that no treatment gives consistent results. The closest treatment to giving consistent results is the granular application; however, it is not significant at the 5% level in any of the areas except the Bird Area where the value of "t" was highly significant - the 1% level.

More sophisticated analysis such as transformations will be tried to overcome the inconsistencies found above. More years of data may be necessary.

TABLE 2: COMPARISON OF EACH ALDRIN TREATMENT WITH THE CHECK AND OF THE ALDRIN TREATMENTS WITH EACH OTHER.

Comparison	Area	Grubs Per Cu. Ft.	F	Treatment 4-1 t	4-1 Dr	4-2 t	4-2 Dr	4-3 t	4-3 Dr	3-2 t	3-2 Dr	3-1 t	3-1 Dr	2-1 t	2-1 Dr
All damaged trees dug living	Bird Area	0.33	NS	NS	NS	*	*	*	*	NS	NS	NS	NS	NS	NS
	Raco	1.10	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
	Townhall	1.23	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Townline Lk.	1.40	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Heavily damaged living trees	Bird Area	0.33	NS	NS	NS	**	*	**	**	NS	NS	NS	NS	NS	NS
	Raco	1.10	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	**	NS
	Townhall	1.23	*	*	*	*	*	NS	NS	NS	NS	NS	NS	NS	NS
	Townline Lk.	1.40	NS	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS

F = F test, t = "t" test, Dr = Duncan range test
NS = Not significant,
* = Significant at the 5% level
** = Significant at the 1 % level

Treatment 1 = Liquid aldrin by machine
Treatment 2 = Liquid aldrin by hand
Treatment 3 = Granular aldrin by machine
Treatment 4 = No aldrin

SUMMARY

A root scoring system was developed and has been used to assign the examined root systems into seven classes. These seven classes were then combined into three damage categories - no grub damage, moderately damaged and heavily damaged. These categories were used in the discussion of the feeding damage and in the statistical analysis.

The high survival rate in all areas is impressive at first glance as it ranges from 96 to almost 98½%; however it is not uncommon to have high initial survival even where grub losses are found to be heavy in later surveys.

When living trees were dug and examined the bright survival picture darkened considerably. Table 2 shows that even trees that had been protected suffered damage. From 6 to 28% of the trees had been moderately damaged, and an additional 0 to 28% of the trees had been heavily damaged. What effect this feeding damage has on the living trees remains to be seen. It can be said with a great deal of certainty that the "living" trees in Classes 4 and 5 are lost. Perhaps the class 3½'s should be included also. Time will tell.

The statistical analysis to date failed to establish that any of the aldrin treatments gave consistantly better protection than no treatment at all. More sophisticated procedures may help and/or more years of data may be necessary.

RECOMMENDATIONS

1. In spite of the failure, of the work done so far, to establish that aldrin treatment consistently gives protection, it is recommended that the use of liquid aldrin by machine be continued in Spring 1968 original plantings where grub populations are suspected and in Spring 1968 replantings where grub feeding damage is known to have occurred.

2. Further it is recommended that the use of liquid aldrin by hand application be continued in Spring 1968 hand planting of original areas where grub populations are suspected and in Spring 1968 replantings where grub feeding damage is known to have occurred.

3. Closer supervision of the mixing of liquid aldrin if the above treatments are made.

4. Proceed slowly with developing a granular aldrin application if increased tree protection is the major objective of this form of the insecticide since the results to date are not encouraging.

APPENDIX A

MIXING AND APPLICATION OF LIQUID ALDRIN

This section rightfully belongs in the Establishment Report. It was omitted because errors in mixing the aldrin appeared to have occurred, and rather than delay the Establishment Report, this section was deleted. It is appended to this report so that it will become part of the record.

The aldrin evaluation plots (Objective 1) of the Plan were established in the spring of 1967 on the Hiawatha National Forest (seeEstablishment Report). Two unexpected problems arose that may muddy the water as comparisons of the treatments are made.

The first concerns the dose rate of aldrin used. The planting machines equipped with the attachments to apply the liquid aldrin (Treatment 1) are not rigged with a device to meter out a specified amount of aldrin mixture each time the valve is activated. Therefore, each planter applied a different amount of aldrin, depending upon his style of planting. Fortunately this difference was reduced some by having the same man and machine used on the Bird and Townline Lake areas and the same man and machine used on the Raco and Townhall areas.

The applications by backpack pump (Treatment 2) also varied depending on which pump was used. Three different pumps were used but all of this treatment in all five areas was applied by the same man.

The measurements to ascertain the average amount of aldrin mixture applied by each planter operating his particular machine was obtained by placing a graduate cylinder under the machine (with the dispensor nozzle directed into it) and having the planter simulate planting of ten trees while operating the applicator. The meniscus was read and the number divided by ten to arrive at an average figure. The "aljectors" were checked in a similar manner. The operator put the nozzle into the graduate cylinder and squeezed the lever ten times. Again the measured amount of solution in the cylinder was divided by ten for the average figure.

The second problem came to light after the plots had been established. Errors were made when the districts mixed the field strength solution from the aldrin concentrate. A dose of 1% aldrin was intended. However, the Manistique District mixed it at 0.33% and the Soo District at 1.2%. This error is partly compensated for in that inadvertently

a larger quantity of the Manistique District's mixture was applied to each tree. Table 3 summarizes the amounts and concentrations of liquid aldrin used in each area. Conversions were made to put all the liquid applications on a base of 1% aldrin so that comparisons can be made later.

TABLE 3: ALDRIN MIXTURE AND AMOUNT USED PER TREE IN EACH ALDRIN EVALUATION AREA. THE ACTUAL AMOUNT AND THE CONVERSION TO THE RECOMMENDED 1% ACTIVE SOLUTION.[1]

Treatment	Mixture	Raco		Highbanks		Townhall		Townline Lk.		Bird	
		Actual	Conv.	Actual	Conv.	Actual	Conv.	Actual	Conv.	Actual	Conv.
1	% Aldrin	1.2	1	1.2	1	1.2	1	0.33	1	0.33	1
	ml/tree	11.4	13.7	?	?	11.4	13.7	17.6	5.8	17.6	5.8
2	% Aldrin	1.2	1	1.2	1	1.2	1	0.33	1	0.33	1
	ml/tree	8.8	10.6	8.8	10.6	8.8	10.6	11.4	3.7	13.8	4.6
3	% Active	20	----	20	----	20	----	20	---	20	---
	gm/tree[2]	9.3	----	9.3	----	9.3	----	9.3	---	9.3	---
4	% Active	----	----	----	----	----	----	-----	---	-----	---
	ml/tree	----	----	----	----	----	----	----	---	----	---

1. This conversion was made by multiplying the average dose per tree by the percent of active aldrin in the mixture. This was done to give a common base for comparisons to be made later.

2. The granular aldrin was measured in the same (milimeter) graduate cylinder and converted to grams thus this is an approximate figure.

DISTRIBUTION

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North Central Forest Experiment Station (Dr. Wilson)	2

* Copy(s) of establishment report included

** Copy(s) of plan and establishment included